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THE METRIC SYSTEM

CONVERSION FACTORS
DIRECT CONVERSION TABLES

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PREFACE

The purpose of this publication is to provide certain basic information to users of the Metric System within the Center. It contains a list of conversion factors and direct conversion tables for those units of measurement which are most frequently used in Center reporting.

Much of the information herein was obtained from the National Bureau of Standards which the Center will use as the authoritative source in metric conversion.

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Brief History of

MEASUREMENT SYSTEMS

"Weights and measures may be ranked among the necessaries of life to every individual of human society. They enter into the economical arrangements and daily concerns of every family. They are necessary to every occupation of human industry; to the distribution and security of every species of property; to every transaction of trade and commerce; to the labors of the husbandman; to the ingenuity of the artificer; to the studies of the philosopher; to the researches of the antiquarian, to the navigation of the mariner, and the marches of the soldier; to all the exchanges of peace, and all the operations of war. The knowledge of them, as in established use, is among the first elements of education, and is often learned by those who learn nothing else, not even to read and write. This knowledge is riveted in the memory by the habitual application of it to the employments of men throughout life."

JOHN QUINCY ADAMS
Report to the Congress, 1821

Weights and measures were among the earliest tools invented by man. Primitive societies needed rudimentary measures for many tasks: constructing dwellings of an appropriate size and shape, fashioning clothing, or bartering food or raw materials.

Man understandably turned first to parts of his body and his natural surroundings for measuring instruments. Early Babylonian and Egyptian records and the Bible indicate that length was first measured with the forearm, hand, or finger and that time was measured by the periods of the sun, moon, and other heavenly bodies. When it was necessary to compare the capacities of containers such as gourds or clay or metal vessels, they were filled with plant seeds which were then counted to measure the volumes. When means for weighing were invented, seeds and stones served as standards. For instance, the "carat," still used as a unit for gems, was derived from the carob seed.

As societies evolved, weights and measures became more complex. The invention of numbering systems and the science of mathematics made it possible to create whole systems of weights and measures suited to trade and commerce, land division, taxation, or scientific research. For these more sophisticated uses it was necessary not only to weigh and measure more complex things—it was also necessary to do it accurately time after time and in different places. However, with limited international exchange of goods and communication of ideas, it is not surprising that different systems for the same purpose developed and became established in different parts of the world—even in different parts of a single continent.

The English System

The measurement system commonly used in the United States today is nearly the same as that brought by the colonists from England. These measures had their origins in a variety of cultures—Babylonian, Egyptian, Roman, Anglo-Saxon, and Norman French. The ancient "digit." "palm." "span," and "cubit" "units evolved into the "inch," "foot," and "yard" through a complicated transformation not yet fully understood.

Roman contributions include the use of the number 12 as a base (our foot is divided into 12 inches) and words from which we derive many of our present weights and measures names. For example, the 12 divisions of the Roman "pes," or foot, were called *unciae.* Our words "inch" and "ounce" are both derived from that Latin word.

The "yard" as a measure of length can be traced back to the early Saxon kings. They wore a sash or girdle around the waist—that could be removed and used as a convenient measuring device. Thus the word "yard" comes from the Saxon word "gird" meaning the circumference of a person's waist.

Standardization of the various units and their combinations into a loosely related system of weights and measures sometimes occurred in fascinating ways. Tradition holds that King Henry I decreed that the yard should be the distance from the tip of his nose to the end of his thumb. The length of a furlong (or furrow-long) was established by early Tudor rulers as 220 yards. This led Queen Elizabeth I to declare, in the 16th century, that henceforth the traditional Roman mile of 5,000 feet would be replaced by one of 5,280 feet, making the mile exactly 8 furlongs and providing a convenient relationship between two previously ill-related measures.

Thus, through royal edicts, England by the 18th century had achieved a greater degree of standardization than the continental countries. The English units were well suited to commerce and trade because they had been developed and refined to meet commercial needs. Through colonization and dominance of world commerce during the 17th, 18th, and 19th centuries, the English system of weights and measures was spread to and established in many parts of the world, including the American colonies.

However, standards still differed to an extent undesirable for commerce among the 13 colonies. The need for greater uniformity led to clauses in the Articles of Confederation (ratified by the original colonies in 1781) and the Constitution of the United States (ratified in 1790) giving power to the Congress to fix uniform standards for weights and measures. Today, standards supplied to all the States by the National Bureau of Standards assure uniformity throughout the country.

The Metric System

The need for a single worldwide coordinated measurement system was recognized over 300 years ago. Gabriel Mouton, Vicar of St. Paul in Lyons, proposed in 1670 a comprehensive decimal measurement system based on the length of one minute of arc of a great circle of the earth. In 1671 Jean Picard, A French astronomer. proposed the length of a pendulum beating seconds as the unit of length. (Such a pendulum would have been fairly easily reproducible, thus facilitating the widespread distribution of uniform standards.) Other proposals were made, but over a century elapsed before any action was taken.

In 1790, in the midst of the French Revolution the National Assembly of France requested the French Academy of Sciences to "deduce an invariable standard for all the measures and all the weights." The Commission appointed by the Academy created a system that was, at once, simple and scientific. The unit of length was to be a portion of the earth's circumference. Measures for capacity (volume) and mass (weight) were to be derived from the unit of length, thus relating the basic units of the system to each other and to nature. Furthermore, the larger and smaller versions of each unit were to be created by multiplying or dividing the basic units by 10 and its multiples. This feature provided a great convenience to users of the system, by eliminating the need for such calculations as dividing by 16 (to convert ounces to pounds) or by 12 (to convert inches to feet). Similar calculations in the metric system could be performed simply by shifting the decimal point. Thus the metric system is a "base-10" or "decimal" system.

The Commission assigned the name metre (which we also spell meter) to the unit of length. This name was derived from the Greek word metron, meaning "a measure." The physical standard representing the meter was to be constructed so that it would equal one ten-millionth of the distance from the north pole to the equator along the meridian of the earth running near Dunkirk in France and Barcelona in Spain.

The metric unit of mass, called the "gram," was defined as the mass of one cubic centimeter (a cube that is 1/100 of a meter on each side) of water at its temperature of maximum density. The cubic decimeter (a cube 1/10 of a meter on each side) was chosen as the unit of fluid capacity. This measure was given the name "liter."

Although the metric system was not accepted with enthusiasm at first, adoption by other nations, occurred steadily after France made its use compulsory in 1840. The standardized character and decimal features of the metric system made it well suited to scientific and engineering work. Consequently, it is not surprising that the rapid spread of the system coincided with an age of rapid technological development. In the United States, by Act of Congress in 1866, it was made "lawful throughout the United States of America to employ the weights and measures of the metric system in all contracts, dealings or court proceedings."

By the late 1860's, even better metric standards were needed to keep pace with scientific advances. In 1875, an international treaty, the "Treaty of the Meter," set up well-defined metric standards for length and mass, and established permanent machinery to recommend and adopt further refinements in the metric system. This treaty, known as the Metric Convention, was signed by 17 countries, including the United States.

As a result of the Treaty, metric standards were constructed and distributed to each nation that ratified the Convention. Since 1893, the internationally agreed-to metric standards have served as the fundamental weights and measures standards of the United States.

By 1900 a total of 35 nations—including the major nations of continental Europe and most of South America—had officially accepted the metric system. In 1971 the Secretary of Commerce, in transmitting to Congress the results of a 3-year study authorized by the Metric Study Act of 1968, recommended that the U.S. change to predominant use of the metric system through a coordinated national program.

In 1975 the President signed the "Metric Conversion Act of 1975". Its purpose is "To declare a national policy of coordinating the increasing use of the Metric System within the United States and to establish a United States Metric Board to coordinate the voluntary conversion to the Metric System".

The International Bureau of Weights and Measures located at Sevres, France, serves as a permanent secretariat for the Metric Convention, coordinating the exchange of information about the use and refinement of the metric system. As measurement science develops more precise and easily reproducible ways of defining the measurement units, the General Conference of Weights and Measures—the diplomatic organization made up of adherents to the Convention—meets periodically to ratify improvements in the system and the standards.

In 1960, the General Conference adopted an extensive revision and simplification of the system. The name *Le Systeme International d'Unites* (International System of Units), with the international abbreviation SI, was adopted for this modernized metric system. Further improvements in and additions to SI were made by the General Conference in 1964, 1968, and 1971.

DEFINITIONS

In its original conception, the meter was the fundamental unit of the Metric System, and all units of length and capacity were to be derived directly from the meter which was intended to be equal to one ten-millionth of the earth's quadrant. Furthermore, it was originally planned that the unit of mass, the kilogram, should be identical with the mass of a cubic decimeter of water at its maximum density. The units of length and mass are now defined independently of these conceptions.

In October 1960 the Eleventh General (International) Conference on Weights and Measures redefined the meter as equal to 1 650 763.73 wavelengths of the orange-red radiation in vacuum of krypton 86 corresponding to the unperturbed transition between the $2p^{10}$ and $5d^{5}$ levels.

The kilogram is independently defined as the mass of a particular platinum-iridium standard, the International Prototype Kilogram, which is kept at the International Bureau of Weights and Measures in Sevres, France.

The liter has been defined, since October 1964, as being equal to a cubic decimeter. The meter is thus a unit on which is based all metric standards and measurements of length, area, and volume.

Definitions of Units

Length

A *meter* is a unit of length equal to 1 650 763.73 wavelengths in a vacuum of the orange-red radiation of krypton 86.

Mass

A *kilogram* is a unit of mass equal to the mass of the International Prototype Kilogram.

Capacity, or Volume

A *cubic meter* is a unit of volume equal to a cube the edges of which are 1 meter.

A *liter* is a unit of volume equal to a cubic decimeter.

Area

A *square meter* is a unit of area equal to the area of a square the sides of which are 1 meter.

A *hectare* is a unit of area equal to the area of a square the sides of which are 100 meters.

Spelling and Symbols for Units

The spelling of the names of units as adopted by the National Bureau of Standards is that given in the list below. The spelling of the metric units is in accordance with that given in the law of July 28, 1866, legalizing the Metric System in the United States.

Following the name of each unit in the list below is given the symbol that the Bureau has adopted. Attention is particularly called to the following principles:

1. No period is used with symbols for units. Whenever "in" for inch might be confused with the preposition "in", "inch" should be spelled out.
2. The exponents "2" and "3" are used to signify "square" and "cubic," respectively, instead of the symbols "sq" or "cu," which are, however, frequently used in technical literature for the U.S. Customary units.
3. The same symbol is used for both singular and plural.

Some Units and Their Symbols

Unit	Symbol	Unit	Symbol	Unit	Symbol
acre	acre	dekaliter	dal	milligram	mg
barrel	bbl	dekameter	dam	milliliter	ml
bushel	bu	Fahrenheit	°F	millimeter	mm
Celsius, degree	°C	foot	ft	second	s
centigram	cg	gallon	gal	square centimeter	cm^2
centiliter	cl	gram	g	square decimeter	dm^2
centimeter	cm	hectare	ha	square dekameter	dam^2
cubic centimeter	cm^3	hectogram	hg	square foot	ft^2
cubic decimeter	dm^3	hectoliter	hl	square hectometer	hm^2
cubic dekameter	dam^3	hectometer	hm	square inch	in^2
cubic foot	ft^3	inch	in	square kilometer	km^2
cubic hectometer	hm^3	Nautical Mile	NM	square meter	m^2
cubic inch	in^3	Kelvin, degree	°K	square mile	mi^2
cubic kilometer	km^3	kilogram	kg	square millimeter	mm^2
cubic meter	m^3	kiloliter	kl	square yard	yd^2
cubic mile	mi^3	kilometer	km	ton, long	long ton
cubic millimeter	mm^3	liter	liter	ton, metric	t
cubic yard	yd^3	meter	m	ton, short	short ton
decigram	dg	microgram	μg	yard	yd
deciliter	dl	microliter	μl		
decimeter	dm	micrometer	μm		
dekagram	dag	mile	mi		

Factor	Prefix	Symbol	Factor	Prefix	Symbol
10^{12}	tera	T	10^{-1}	deci	d
10^{9}	giga	G	10^{-2}	centi	c
10^{6}	mega	M	10^{-3}	milli	m
10^{3}	kilo	k	10^{-6}	micro	μ
10^{2}	hecto	h	10^{-9}	nano	n
10^{1}	deka	da	10^{-12}	pico	p
			10^{-15}	femto	f
			10^{-18}	atto	a

The following lists of conversion factors are based on National Bureau of Standards values and are rounded to four decimal places. The listings contain most of the units used in Center publications. Users should round the results to suit their needs. For additional information on units not listed in the tables call [redacted]

25X1A

List of Conversion Factors by Classification

UNITS OF LENGTH

IF YOU HAVE	MULTIPLY BY	TO OBTAIN
MILLIMETERS	0.0394	INCHES
CENTIMETERS	0.3937	INCHES
INCHES	25.4000	MILLIMETERS
INCHES	2.5400	CENTIMETERS
FEET	0.3048	METERS
FEET	0.0003	KILOMETERS
YARDS	0.9144	METERS
METERS	3.2808	FEET
METERS	0.0005	MILES(NAUTICAL)
METERS	1.0936	YARDS
KILOMETERS	3280.8400	FEET
KILOMETERS	0.6214	MILES(STATUTE)
KILOMETERS	0.5400	MILES(NAUTICAL)
MILES(STATUTE)	1.6093	KILOMETERS
MILES(NAUTICAL)	6076.1154	FEET
MILES(NAUTICAL)	1.8520	KILOMETERS
MILES(NAUTICAL)	1852.0000	METERS

UNITS OF AREA

IF YOU HAVE	MULTIPLY BY	TO OBTAIN
SQUARE CENTIMETERS	0.1550	SQUARE INCHES
SQUARE INCHES	6.4516	SQUARE CENTIMETERS
SQUARE FEET	0.0929	SQUARE METERS
SQUARE YARDS	0.8361	SQUARE METERS
SQUARE METERS	10.7639	SQUARE FEET
SQUARE METERS	1.1960	SQUARE YARDS
SQUARE METERS	1.0000	CENTARES
SQUARE METERS	0.0002	ACRES
SQUARE METERS	0.0001	HECTARES
ACRES	4046.8564	SQUARE METERS
ACRES	0.4047	HECTARES
HECTARES	10000.0000	SQUARE METERS
HECTARES	2.4711	ACRES

UNITS OF MASS

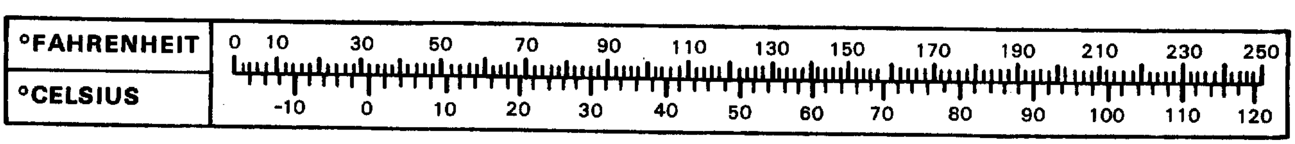
IF YOU HAVE	MULTIPLY BY	TO OBTAIN
KILOGRAMS	2.2046	POUNDS(AVOIR.)
POUNDS(AVOIR.)	0.4536	KILOGRAMS
SHORT TONS	0.9072	METRIC TONS
METRIC TONS	1.1023	SHORT TONS
METRIC TONS	0.9842	LONG TONS
LONG TONS	1.0160	METRIC TONS

UNITS OF VOLUME

IF YOU HAVE	MULTIPLY BY	TO OBTAIN
LITERS	0.2642	GALLONS
LITERS	0.0063	BARRELS(POL)
LITERS	0.0010	CUBIC METERS
GALLONS	3.7854	LITERS
GALLONS	0.1337	CUBIC FEET
GALLONS	0.0238	BARRELS(POL)
GALLONS	0.0038	CUBIC METERS
BUSHELS	0.0352	CUBIC METERS
CUBIC FEET	7.4805	GALLONS
CUBIC FEET	0.1781	BARRELS(POL)
CUBIC FEET	0.0283	CUBIC METERS
CUBIC YARDS	0.7646	CUBIC METERS
BARRELS(POL)	158.9873	LITERS
BARRELS(POL)	42.0000	GALLONS
BARRELS(POL)	5.6146	CUBIC FEET
BARRELS(POL)	0.1590	CUBIC METERS
CUBIC METERS	1000.0000	LITERS
CUBIC METERS	264.1721	GALLONS
CUBIC METERS	35.3147	CUBIC FEET
CUBIC METERS	28.3776	BUSHELS
CUBIC METERS	6.2898	BARRELS(POL)
CUBIC METERS	1.3080	CUBIC YARDS

UNITS OF TEMPERATURE

(°FAHRENHEIT MINUS 32) DIVIDED BY 1.8 = °CELSIUS (CENTIGRADE)
(°CELSIUS MULTIPLIED BY 1.8) PLUS 32 = °FAHRENHEIT



LENGTH - FEET TO METERS 1 FOOT = C.3048 METER

Ft.	Meter
0.1	0.0305
0.2	0.0610
0.3	0.0914
0.4	0.1219
0.5	0.1524
0.6	0.1829
0.7	0.2134
0.8	0.2438
0.9	0.2743

FEET	METERS	FEET	METERS	FEET	METERS	FEET	METERS	FEET	METERS
0	0.0000	100	30.4800	200	60.9600	300	91.4400	400	121.9200
1	0.3048	101	30.7848	201	61.2648	301	91.7448	401	122.2248
2	0.6096	102	31.0896	202	61.5696	302	92.0496	402	122.5296
3	0.9144	103	31.3944	203	61.8744	303	92.3544	403	122.8344
4	1.2192	104	31.6992	204	62.1792	304	92.6592	404	123.1392
5	1.5240	105	32.0040	205	62.4840	305	92.9640	405	123.4440
6	1.8288	106	32.3088	206	62.7888	306	93.2688	406	123.7488
7	2.1336	107	32.6136	207	63.0936	307	93.5736	407	124.0536
8	2.4384	108	32.9184	208	63.3984	308	93.8784	408	124.3584
9	2.7432	109	33.2232	209	63.7032	309	94.1832	409	124.6632
10	3.0480	110	33.5280	210	64.008C	310	94.4880	410	124.9680
11	3.3528	111	33.8328	211	64.3128	311	94.7928	411	125.2728
12	3.6576	112	34.1376	212	64.6176	312	95.0976	412	125.5776
13	3.9624	113	34.4424	213	64.9224	313	95.4024	413	125.8824
14	4.2672	114	34.7472	214	65.2272	314	95.7072	414	126.1872
15	4.5720	115	35.0520	215	65.532C	315	96.0120	415	126.4920
16	4.8768	116	35.3568	216	65.8368	316	96.3168	416	126.7968
17	5.1816	117	35.6616	217	66.1416	317	96.6216	417	127.1016
18	5.4864	118	35.9664	218	66.4464	318	96.9264	418	127.4064
19	5.7912	119	36.2712	219	66.7512	319	97.2312	419	127.7112
20	6.0960	120	36.5760	220	67.056C	320	97.5360	420	128.0160
21	6.4008	121	36.8808	221	67.3608	321	97.8408	421	128.3208
22	6.7056	122	37.1856	222	67.6656	322	98.1456	422	128.6256
23	7.0104	123	37.4904	223	67.9704	323	98.4504	423	128.9304
24	7.3152	124	37.7952	224	68.2752	324	98.7552	424	129.2352
25	7.6200	125	38.1000	225	68.580C	325	99.0600	425	129.5400
26	7.9248	126	38.4048	226	68.8848	326	99.3648	426	129.8448
27	8.2296	127	38.7096	227	69.1896	327	99.6696	427	130.1496
28	8.5344	128	39.0144	228	69.4944	328	99.9744	428	130.4544
29	8.8392	129	39.3192	229	69.7992	329	100.2792	429	130.7592
30	9.1440	130	39.6240	230	70.104C	330	100.5840	430	131.0640
31	9.4488	131	39.9288	231	70.4088	331	100.8888	431	131.3688
32	9.7536	132	40.2336	232	70.7136	332	101.1936	432	131.6736
33	10.0584	133	40.5384	233	71.0184	333	101.4984	433	131.9784
34	10.3632	134	40.8432	234	71.3232	334	101.8032	434	132.2832
35	10.6680	135	41.1480	235	71.628C	335	102.1080	435	132.5880
36	10.9728	136	41.4528	236	71.9328	336	102.4128	436	132.8928
37	11.2776	137	41.7576	237	72.2376	337	102.7176	437	133.1976
38	11.5824	138	42.0624	238	72.5424	338	103.0224	438	133.5024
39	11.8872	139	42.3672	239	72.8472	339	103.3272	439	133.8072
40	12.1920	140	42.6720	240	73.152C	340	103.6320	440	134.1120
41	12.4968	141	42.9768	241	73.4568	341	103.9368	441	134.4168
42	12.8016	142	43.2816	242	73.7616	342	104.2416	442	134.7216
43	13.1064	143	43.5864	243	74.0664	343	104.5464	443	135.0264
44	13.4112	144	43.8912	244	74.3712	344	104.8512	444	135.3312
45	13.7160	145	44.1960	245	74.676C	345	105.1560	445	135.6360
46	14.0208	146	44.5008	246	74.9808	346	105.4608	446	135.9408
47	14.3256	147	44.8056	247	75.2856	347	105.7656	447	136.2456
48	14.6304	148	45.1104	248	75.5904	348	106.0704	448	136.5504
49	14.9352	149	45.4152	249	75.8952	349	106.3752	449	136.8552

Continued - FEET TO METERS 1 FOOT = C.3048 METER

Ft.	= Meter
0.1	= 0.0305
0.2	= 0.0610
0.3	= 0.0914
0.4	= 0.1219
0.5	= 0.1524
0.6	= 0.1829
0.7	= 0.2134
0.8	= 0.2438
0.9	= 0.2743

FEET	METERS	FEET	METERS	FEET	METERS	FEET	METERS	FEET	METERS
50	15.2400	150	45.7200	250	76.2000	350	106.6800	450	137.1600
51	15.5448	151	46.0248	251	76.5048	351	106.9848	451	137.4648
52	15.8496	152	46.3296	252	76.8096	352	107.2896	452	137.7696
53	16.1544	153	46.6344	253	77.1144	353	107.5944	453	138.0744
54	16.4592	154	46.9392	254	77.4192	354	107.8992	454	138.3792
55	16.7640	155	47.2440	255	77.724C	355	108.2040	455	138.6840
56	17.0688	156	47.5488	256	78.0288	356	108.5088	456	138.9888
57	17.3736	157	47.8536	257	78.3336	357	108.8136	457	139.2936
58	17.6784	158	48.1584	258	78.6384	358	109.1184	458	139.5984
59	17.9832	159	48.4632	259	78.9432	359	109.4232	459	139.9032
60	18.2880	160	48.7680	260	79.2480	360	109.7280	460	140.2080
61	18.5928	161	49.0728	261	79.5528	361	110.0328	461	140.5128
62	18.8976	162	49.3776	262	79.8576	362	110.3376	462	140.8176
63	19.2024	163	49.6824	263	80.1624	363	110.6424	463	141.1224
64	19.5072	164	49.9872	264	80.4672	364	110.9472	464	141.4272
65	19.8120	165	50.2920	265	80.7720	365	111.2520	465	141.7320
66	20.1168	166	50.5968	266	81.0768	366	111.5568	466	142.0368
67	20.4216	167	50.9016	267	81.3816	367	111.8616	467	142.3416
68	20.7264	168	51.2064	268	81.6864	368	112.1664	468	142.6464
69	21.0312	169	51.5112	269	81.9912	369	112.4712	469	142.9512
70	21.3360	170	51.8160	270	82.296C	370	112.7760	470	143.2560
71	21.6408	171	52.1208	271	82.6008	371	113.0808	471	143.5608
72	21.9456	172	52.4256	272	82.9056	372	113.3856	472	143.8656
73	22.2504	173	52.7304	273	83.2104	373	113.6904	473	144.1704
74	22.5552	174	53.0352	274	83.5152	374	113.9952	474	144.4752
75	22.8600	175	53.3400	275	83.8200	375	114.3000	475	144.7800
76	23.1648	176	53.6448	276	84.1248	376	114.6048	476	145.0848
77	23.4696	177	53.9496	277	84.4296	377	114.9096	477	145.3896
78	23.7744	178	54.2544	278	84.7344	378	115.2144	478	145.6944
79	24.0792	179	54.5592	279	85.0392	379	115.5192	479	145.9992
80	24.3840	180	54.8640	280	85.3440	380	115.8240	480	146.3040
81	24.6888	181	55.1688	281	85.6488	381	116.1288	481	146.6088
82	24.9936	182	55.4736	282	85.9536	382	116.4336	482	146.9136
83	25.2984	183	55.7784	283	86.2584	383	116.7384	483	147.2184
84	25.6032	184	56.0832	284	86.5632	384	117.0432	484	147.5232
85	25.9080	185	56.3880	285	86.8680	385	117.3480	485	147.8280
86	26.2128	186	56.6928	286	87.1728	386	117.6528	486	148.1328
87	26.5176	187	56.9976	287	87.4776	387	117.9576	487	148.4376
88	26.8224	188	57.3024	288	87.7824	388	118.2624	488	148.7424
89	27.1272	189	57.6072	289	88.0872	389	118.5672	489	149.0472
90	27.4320	190	57.9120	290	88.3920	390	118.8720	490	149.3520
91	27.7368	191	58.2168	291	88.6968	391	119.1768	491	149.6568
92	28.0416	192	58.5216	292	89.0016	392	119.4816	492	149.9616
93	28.3464	193	58.8264	293	89.3064	393	119.7864	493	150.2664
94	28.6512	194	59.1312	294	89.6112	394	120.0912	494	150.5712
95	28.9560	195	59.4360	295	89.9160	395	120.3960	495	150.8760
96	29.2608	196	59.7408	296	90.2208	396	120.7008	496	151.1808
97	29.5656	197	60.0456	297	90.5256	397	121.0056	497	151.4856
98	29.8704	198	60.3504	298	90.8304	398	121.3104	498	151.7904
99	30.1752	199	60.6552	299	91.1352	399	121.6152	499	152.0952

Continued - FEET TO METERS 1 FOOT = 0.3048 METER

Ft.	= Meter
0.1	= 0.0305
0.2	= 0.0610
0.3	= 0.0914
0.4	= 0.1219
0.5	= 0.1524
0.6	= 0.1829
0.7	= 0.2134
0.8	= 0.2438
0.9	= 0.2743

FEET	METERS	FEET	METERS	FEET	METERS	FEET	METERS	FEET	METERS
500	152.4000	600	182.8800	700	213.3600	800	243.8400	900	274.3200
501	152.7048	601	183.1848	701	213.6648	801	244.1448	901	274.6248
502	153.0096	602	183.4896	702	213.9696	802	244.4496	902	274.9296
503	153.3144	603	183.7944	703	214.2744	803	244.7544	903	275.2344
504	153.6192	604	184.0992	704	214.5792	804	245.0592	904	275.5392
505	153.9240	605	184.4040	705	214.8840	805	245.3640	905	275.8440
506	154.2288	606	184.7088	706	215.1888	806	245.6688	906	276.1488
507	154.5336	607	185.0136	707	215.4936	807	245.9736	907	276.4536
508	154.8384	608	185.3184	708	215.7984	808	246.2784	908	276.7584
509	155.1432	609	185.6232	709	216.1032	809	246.5832	909	277.0632
510	155.4480	610	185.9280	710	216.4080	810	246.8880	910	277.3680
511	155.7528	611	186.2328	711	216.7128	811	247.1928	911	277.6728
512	156.0576	612	186.5376	712	217.0176	812	247.4976	912	277.9776
513	156.3624	613	186.8424	713	217.3224	813	247.8024	913	278.2824
514	156.6672	614	187.1472	714	217.6272	814	248.1072	914	278.5872
515	156.9720	615	187.4520	715	217.9320	815	248.4120	915	278.8920
516	157.2768	616	187.7568	716	218.2368	816	248.7168	916	279.1968
517	157.5816	617	188.0616	717	218.5416	817	249.0216	917	279.5016
518	157.8864	618	188.3664	718	218.8464	818	249.3264	918	279.8064
519	158.1912	619	188.6712	719	219.1512	819	249.6312	919	280.1112
520	158.4960	620	188.9760	720	219.4560	820	249.9360	920	280.4160
521	158.8008	621	189.2808	721	219.7608	821	250.2408	921	280.7208
522	159.1056	622	189.5856	722	220.0656	822	250.5456	922	281.0256
523	159.4104	623	189.8904	723	220.3704	823	250.8504	923	281.3304
524	159.7152	624	190.1952	724	220.6752	824	251.1552	924	281.6352
525	160.0200	625	190.5000	725	220.9800	825	251.4600	925	281.9400
526	160.3248	626	190.8048	726	221.2848	826	251.7648	926	282.2448
527	160.6296	627	191.1096	727	221.5896	827	252.0696	927	282.5496
528	160.9344	628	191.4144	728	221.8944	828	252.3744	928	282.8544
529	161.2392	629	191.7192	729	222.1992	829	252.6792	929	283.1592
530	161.5440	630	192.0240	730	222.5040	830	252.9840	930	283.4640
531	161.8488	631	192.3288	731	222.8088	831	253.2888	931	283.7688
532	162.1536	632	192.6336	732	223.1136	832	253.5936	932	284.0736
533	162.4584	633	192.9384	733	223.4184	833	253.8984	933	284.3784
534	162.7632	634	193.2432	734	223.7232	834	254.2032	934	284.6832
535	163.0680	635	193.5480	735	224.0280	835	254.5080	935	284.9880
536	163.3728	636	193.8528	736	224.3328	836	254.8128	936	285.2928
537	163.6776	637	194.1576	737	224.6376	837	255.1176	937	285.5976
538	163.9824	638	194.4624	738	224.9424	838	255.4224	938	285.9024
539	164.2872	639	194.7672	739	225.2472	839	255.7272	939	286.2072
540	164.5920	640	195.0720	740	225.5520	840	256.0320	940	286.5120
541	164.8968	641	195.3768	741	225.8568	841	256.3368	941	286.8168
542	165.2016	642	195.6816	742	226.1616	842	256.6416	942	287.1216
543	165.5064	643	195.9864	743	226.4664	843	256.9464	943	287.4264
544	165.8112	644	196.2912	744	226.7712	844	257.2512	944	287.7312
545	166.1160	645	196.5960	745	227.0760	845	257.5560	945	288.0360
546	166.4208	646	196.9008	746	227.3808	846	257.8608	946	288.3408
547	166.7256	647	197.2056	747	227.6856	847	258.1656	947	288.6456
548	167.0304	648	197.5104	748	227.9904	848	258.4704	948	288.9504
549	167.3352	649	197.8152	749	228.2952	849	258.7752	949	289.2552

Continued - FEET TO METERS 1 FOOT = 0.3048 METER

Ft.	= Meter
0.1	= 0.0305
0.2	= 0.0610
0.3	= 0.0914
0.4	= 0.1219
0.5	= 0.1524
0.6	= 0.1829
0.7	= 0.2134
0.8	= 0.2438
0.9	= 0.2743

FEET	METERS	FEET	METERS	FEET	METERS	FEET	METERS	FEET	METERS
550	167.6400	650	198.1200	750	228.6000	850	259.0800	950	289.5600
551	167.9448	651	198.4248	751	228.9048	851	259.3848	951	289.8648
552	168.2496	652	198.7296	752	229.2096	852	259.6896	952	290.1696
553	168.5544	653	199.0344	753	229.5144	853	259.9944	953	290.4744
554	168.8592	654	199.3392	754	229.8192	854	260.2992	954	290.7792
555	169.1640	655	199.6440	755	230.1240	855	260.6040	955	291.0840
556	169.4688	656	199.9488	756	230.4288	856	260.9088	956	291.3888
557	169.7736	657	200.2536	757	230.7336	857	261.2136	957	291.6936
558	170.0784	658	200.5584	758	231.0384	858	261.5184	958	291.9984
559	170.3832	659	200.8632	759	231.3432	859	261.8232	959	292.3032
560	170.6880	660	201.1680	760	231.6480	860	262.1280	960	292.6080
561	170.9928	661	201.4728	761	231.9528	861	262.4328	961	292.9128
562	171.2976	662	201.7776	762	232.2576	862	262.7376	962	293.2176
563	171.6024	663	202.0824	763	232.5624	863	263.0424	963	293.5224
564	171.9072	664	202.3872	764	232.8672	864	263.3472	964	293.8272
565	172.2120	665	202.6920	765	233.1720	865	263.6520	965	294.1320
566	172.5168	666	202.9968	766	233.4768	866	263.9568	966	294.4368
567	172.8216	667	203.3016	767	233.7816	867	264.2616	967	294.7416
568	173.1264	668	203.6064	768	234.0864	868	264.5664	968	295.0464
569	173.4312	669	203.9112	769	234.3912	869	264.8712	969	295.3512
570	173.7360	670	204.2160	770	234.6960	870	265.1760	970	295.6560
571	174.0408	671	204.5208	771	235.0008	871	265.4808	971	295.9608
572	174.3456	672	204.8256	772	235.3056	872	265.7856	972	296.2656
573	174.6504	673	205.1304	773	235.6104	873	266.0904	973	296.5704
574	174.9552	674	205.4352	774	235.9152	874	266.3952	974	296.8752
575	175.2600	675	205.7400	775	236.2200	875	266.7000	975	297.1800
576	175.5648	676	206.0448	776	236.5248	876	267.0048	976	297.4848
577	175.8696	677	206.3496	777	236.8296	877	267.3096	977	297.7896
578	176.1744	678	206.6544	778	237.1344	878	267.6144	978	298.0944
579	176.4792	679	206.9592	779	237.4392	879	267.9192	979	298.3992
580	176.7840	680	207.2640	780	237.7440	880	268.2240	980	298.7040
581	177.0888	681	207.5688	781	238.0488	881	268.5288	981	299.0088
582	177.3936	682	207.8736	782	238.3536	882	268.8336	982	299.3136
583	177.6984	683	208.1784	783	238.6584	883	269.1384	983	299.6184
584	178.0032	684	208.4832	784	238.9632	884	269.4432	984	299.9232
585	178.3080	685	208.7880	785	239.2680	885	269.7480	985	300.2280
586	178.6128	686	209.0928	786	239.5728	886	270.0528	986	300.5328
587	178.9176	687	209.3976	787	239.8776	887	270.3576	987	300.8376
588	179.2224	688	209.7024	788	240.1824	888	270.6624	988	301.1424
589	179.5272	689	210.0072	789	240.4872	889	270.9672	989	301.4472
590	179.8320	690	210.3120	790	240.7920	890	271.2720	990	301.7520
591	180.1368	691	210.6168	791	241.0968	891	271.5768	991	302.0568
592	180.4416	692	210.9216	792	241.4016	892	271.8816	992	302.3616
593	180.7464	693	211.2264	793	241.7064	893	272.1864	993	302.6664
594	181.0512	694	211.5312	794	242.0112	894	272.4912	994	302.9712
595	181.3560	695	211.8360	795	242.3160	895	272.7960	995	303.2760
596	181.6608	696	212.1408	796	242.6208	896	273.1008	996	303.5808
597	181.9656	697	212.4456	797	242.9256	897	273.4056	997	303.8856
598	182.2704	698	212.7504	798	243.2304	898	273.7104	998	304.1904
599	182.5752	699	213.0552	799	243.5352	899	274.0152	999	304.4952

NOTES

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

THE MODERNIZED metric system

The International System of Units-SI

is a modernized version of the metric system established by international agreement. It provides a logical and interconnected framework for all measurements in science, industry, and commerce. Officially abbreviated SI, the system is built upon a foundation of seven base units, plus two supplementary units, which appear on this chart along with their definitions. All other SI units are derived from these units. Multiples and submultiples are expressed in a decimal system. Use of metric weights and measures was legalized in the United States in 1866, and since 1893 the yard and pound have been defined in terms of the meter and the kilogram. The base units for time, electric current, amount of substance, and luminous intensity are the same in both the customary and metric systems.

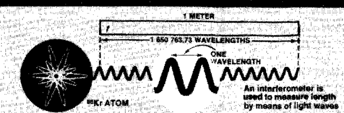
Names of multiples of SI and Metric units are formed by adding a prefix to "meter," "gram," "liter," "watt," or any other unit. Abbreviations use a prefix letter such as "ns" for nanosecond, "kHz" for kilohertz, "mV" for millivolt, etc.

Prefixes	Symbols		Multiples and Submultiples	
tera-	T	10^{12}	1 000 000 000 000	one trillion
giga-	G	10^{9}	1 000 000 000	one billion
mega-	M	10^{6}	1 000 000	one million
kilo-	k	10^{3}	1 000	one thousand
hecto-	h	10^{2}	100	one hundred
deka-	da	10^{1}	10	ten
—	—	10^{0}	1	one
deci-	d	10^{-1}	.1	one tenth
centi-	c	10^{-2}	.01	one hundredth
milli	m	10^{-3}	.001	one thousandth
micro	μ	10^{-6}	.000 001	one millionth
nano	n	10^{-9}	.000 000 001	one billionth
pico	p	10^{-12}	.000 000 000 001	one trillionth
fento	f	10^{-15}	.000 000 000 000 001	one quadrillionth
atto	a	10^{-18}	.000 000 000 000 000 001	one quintillionth

SEVEN BASE UNITS

LENGTH

The meter (common international spelling, metre) is defined as 1 650 763.73 wavelengths in vacuum of the orange-red line of the spectrum of krypton-86.



The SI unit of area is the **square meter** (m^2).

The SI unit of volume is the **cubic meter** (m^3). The liter (0.001 cubic meter), although not an SI unit, is commonly used to measure fluid volume.

MASS

The standard for the unit of mass, the kilogram, is a cylinder of platinum-iridium alloy kept by the International Bureau of Weights and Measures at Paris. A duplicate in the custody of the National Bureau of Standards serves as the mass standard for the United States. This is the only base unit still defined by an artifact.

The SI unit of force is the **newton** (N). One newton is the force which, when applied to a 1 kilogram mass, will give the kilogram mass an acceleration of 1 (meter per second) per second.

$1N = 1kg{\cdot}m/s^2$

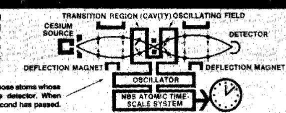
The SI unit for pressure is the **pascal** (Pa).
$1Pa = 1N/m^2$

The SI unit for work and energy of any kind is the **joule** (J).
$1J = 1N{\cdot}m$

The SI unit for power of any kind is the **watt** (W).
$1W = 1J/s$

TIME

The second is defined as the duration of 9 192 631 770 cycles of the radiation associated with a specified transition of the cesium-133 atom. It is realized by tuning an oscillator to the resonance frequency of cesium-133 atoms as they pass through a system of magnets and a resonant cavity into a detector.



Schematic diagram of an atomic beam spectrometer or "clock." Only those atoms whose magnetic moments are "flipped" in the transition region reach the detector. When 9 192 631 770 oscillations have occurred, the clock indicates one second has passed.

The number of periods or cycles per second is called frequency. The SI unit for frequency is the **hertz** (Hz). One hertz equals one cycle per second.

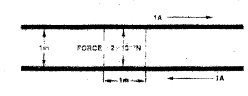
The SI unit for speed is the **meter per second** (m/s).

The SI unit for acceleration is the **(meter per second) per second** (m/s^2).

Standard frequencies and correct time are broadcast from WWV, WWVB, and WWVH and stations of the U.S. Navy. Many shortwave receivers pick up WWV and WWVH on frequencies of 2.5, 5, 10, 15, and 20 megahertz.

ELECTRIC CURRENT

The ampere is defined as that current which, if maintained in each of two long parallel wires separated by one meter in free space, would produce a force between the two wires (due to their magnetic fields) of 2×10^{-7} newton for each meter of length.

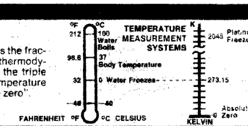


The SI unit of voltage is the **volt** (V).
$1V = 1W/A$

The SI unit of electric resistance is the **ohm** (Ω).
$1\Omega = 1V/A$

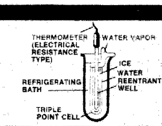
TEMPERATURE

The kelvin is defined as the fraction 1/273.16 of the thermodynamic temperature of the triple point of water. The temperature 0 K is called "absolute zero".



On the commonly used Celsius temperature scale, water freezes at about 0 °C and boils at about 100 °C. The °C is defined as an interval of 1 K, and the Celsius temperature 0 °C is defined as 273.15 K.

1.8 Fahrenheit degrees are equal to 1.0 °C or 1.0 K; the Fahrenheit scale uses 32 °F as a temperature corresponding to 0 °C.



The standard temperature at the triple point of water is provided by a special cell, an evacuated glass cylinder containing pure water. When the cell is cooled until a mantle of ice forms around the reentrant well, the temperature at the interface of solid, liquid, and vapor is 273.16 K. Thermometers to be calibrated are placed in the reentrant well.

mole AMOUNT OF SUBSTANCE

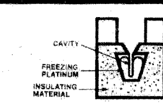
The mole is the amount of substance of a system that contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12.

When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles.

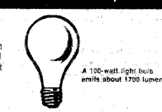
The SI unit of concentration (of amount of substance) is the mole per cubic meter (mol/m^3).

LUMINOUS INTENSITY

The candela is defined as the luminous intensity of 1/600 000 of a square meter of a blackbody at the temperature of freezing platinum (2045 K).



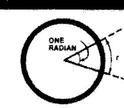
The SI unit of light flux is the lumen (lm). A source having an intensity of 1 candela in all directions radiates a light flux of 4 π lumens.



TWO SUPPLEMENTARY UNITS

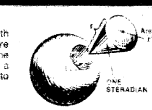
PLANE ANGLE

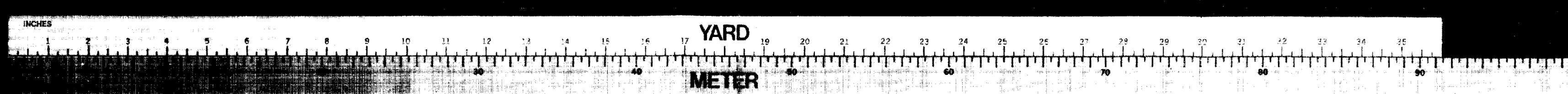
The radian is the plane angle with its vertex at the center of a circle that is subtended by an arc equal in length to the radius.



SOLID ANGLE

The steradian is the solid angle with its vertex at the center of a sphere that is subtended by an area of the spherical surface equal to that of a square with sides equal in length to the radius.





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